

What is claimed is:

1. A probability estimating apparatus for peak-to-peak values in clock
skews among a plurality of clock signals under test, comprising:

5 a clock skew estimator for estimating clock skew sequences among the
plurality of clock signals under test, and

a probability estimator for determining a generation probability of the
peak-to-peak values in the clock skews among the plurality of signals under test
based on the clock skew sequences from the clock skew estimator.

10 2. A probability estimating apparatus for peak-to-peak clock skews as
defined in Claim 1, wherein said probability estimator determines the generation
probability of a peak value of the clock skews among the plurality of signals under test
based on said clock skew sequences.

15 3. An probability estimating apparatus for peak-to-peak clock skews as
defined in Claim 1, wherein said probability estimator is comprised of:

an RMS (root mean square) detector for determining an RMS value of
data of the clock skew sequences supplied thereto;

a memory for storing a predetermined value; and

20 a probability calculator for determining the probability of the peak-to-
peak clock skews among the signals under test which exceeding the
predetermined value based on said predetermined value and said RMS value.

4. A probability estimating apparatus for peak-to-peak clock skews as
defined in Claim 1, wherein said probability estimator is comprised of:

an RMS detector for determining an RMS value of data of the clock
skew sequences supplied thereto;

25 a peak-to-peak detector for calculating maximum and minimum values
of said clock skew sequence data to determine the peak-to-peak value; and

a probability calculator for determining the probability of the clock
skews among the signals under test exceeding the peak-to-peak value based on
said peak-to-peak value and said RMS value of the clock skew sequence data.

30 5. A probability estimating apparatus for peak-to-peak clock skews as

defined in Claim 1, wherein said clock skew estimator is comprised of:

a timing jitter estimator for estimating the timing jitter sequences of the plurality of clock signals under test; and

5 a clock skew calculator for receiving a plurality of said timing jitter sequences and calculating timing difference sequences among said timing jitter sequences.

6. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 5, wherein said clock skew estimator includes a second clock skew calculator for receiving said clock skew sequences to determine the difference among the plurality of said clock skew sequences.

10 7. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 5, wherein said clock skew estimator includes a frequency multiplier for receiving said timing jitter sequences and producing timing jitter sequences which are multiple of a frequency of said signals under test.

15 8. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 5, wherein said clock skew estimator includes a deterministic clock skew estimator for estimating timing errors among ideal clock edges of said plurality of clock signals under test to produce deterministic components of said clock skews.

9. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 5, wherein said timing jitter estimator is comprised of:

20 an analytic signal transformer for transforming the signals under test into analytic signals of complex number;

an instantaneous phase estimator for determining instantaneous phases of the said analytic signals;

25 a linear trend remover for removing linear phases from said instantaneous phases to obtain instantaneous phase noise; and

a zero-crossing resampler for receiving said instantaneous phase noise and resampling said instantaneous phase noise for only closest to zero-crossing timings of real part of the said analytic signals to produce said timing jitter sequences.

30 10. A probability estimating apparatus for peak-to-peak clock skews as

defined in Claim 9, wherein said analytic signal transformer is comprised of:

a band-pass filter for receiving the signals under test and extracting only components closest to a fundamental frequency from the signals under test to band-limit said signals under test; and

5 a Hilbert transformer for Hilbert-transforming output signals of said band-pass filter to generate a Hilbert conversion pair of said signals under test.

11. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 9, wherein said analytic signal transformer is comprised of:

10 a time domain to frequency domain transformer which for transforming the signals under test to both-side spectra signals in the frequency domain;

a bandwidth limiter for extracting only spectral signal components closest to a positive fundamental frequency from said both-side spectra signals; and

15 a frequency domain to time domain transformer for transforming output signals of said bandwidth limiter back to time domain signals.

12. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 9, wherein said analytic signal transformer is comprised of:

a buffer memory for storing the signals under test;

20 means for sequentially extracting the signals under test from said buffer memory while overlapping the extracted signals with a part of the previously extracted signals;

means for multiplying a window function by each of said extracted signals;

25 means for transforming the multiplied extracted signals to both-side spectra signals in a frequency domain;

a bandwidth limiter for extracting only the components closest to a positive fundamental frequency of the signals under test from said both-side spectra signals transformed into the frequency domain;

30 means for transforming output signals of said bandwidth limiter back to time domain signals; and

means for multiplying an inverse window function by the signals transformed into the time domain to obtain band-limited analytic signals.

13. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 5, wherein said clock skew estimator includes an AD (analog-to-digital) converter for converting said signals under test to digital signals.

14. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 5, wherein said clock skew estimator includes a waveform clipper for removing amplitude modulation components of the signals under test and retaining only phase modulation components of the signals under test.

15. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 9, wherein said analytic signal transformer has an adjustable pass band for the signals under test.

16. A probability estimating apparatus for peak-to-peak clock skews as defined in Claim 9, wherein said timing jitter estimator includes a low frequency component remover for removing low frequency components from said instantaneous phase noise and providing resultant instantaneous phase noise to said zero-crossing resampler.

17. A probability estimating method for peak-to-peak values in clock skews among a plurality of clock signals under test, comprising the steps of:

estimating the clock skew sequences among the plurality of clock signals under test; and

determining a generation probability of a peak-to-peak value of the clock skews among the plurality of signals under test based on said clock skew sequences.

18. A probability estimating method for peak-to-peak clock skews as defined in Claim 17, said step of determining the generation probability includes a step of determining a generation probability of peak value of the clock skews among the plurality of signals under test based on said clock skew sequences.

19. A probability estimating method for peak-to-peak clock skews as defined in Claim 17, wherein said step of determining the generation probability of the said

clock skew peak value includes the following steps of:

determining an RMS value of data of said clock skew sequences;

storing a predetermined value in a memory; and

determining the probability of the peak-to-peak clock skews among the

5 plurality of signals under test exceeding the predetermined value based on said predetermined value and said RMS value.

20. A probability estimating method for peak-to-peak clock skews as defined in Claim 17, wherein said step of determining the generation probability of said clock skew peak value includes the following steps of:

10 determining the RMS value of data of said clock skew sequences;

calculating the difference between the maximum and minimum values of said clock skew sequence data to determine the peak-to-peak value;

determining the probability of the clock skews among the signals under test exceeding the peak-to-peak value based on said peak-to-peak value and said RMS
15 value of said clock skew sequence data.

21. A probability estimating method for peak-to-peak clock skews as defined in Claim 17, wherein said step of estimating said clock skew sequences include the following steps of:

estimating timing jitter sequences of the plurality of clock signals under
20 test; and

receiving a plurality of said timing jitter sequences and calculating differences among said timing jitter sequences to estimate the clock skew sequences.

22. A probability estimating method for peak-to-peak clock skews as defined
25 in Claim 21, wherein said step of estimating said clock skew sequences includes a step of receiving said clock skew sequences and determining the difference among the plurality of the clock skew sequences, thereby estimating the probability of peak-to-peak clock skews.

23. A probability estimating method for peak-to-peak clock skews as defined
30 in Claim 21, wherein said step of estimating the said clock skew sequences includes

a step of receiving said timing jitter sequences to estimate timing jitter sequences of signals which are frequency multiplied by said signals under test.

24. A probability estimating method for peak-to-peak clock skews as defined in Claim 21, wherein said step of estimating the clock skew sequences includes a step of estimating timing errors among ideal clock edges of said plurality of clock signals under test to estimate deterministic components of said clock skews.

25. A probability estimating method for peak-to-peak clock skews as defined in Claim 21, wherein said step of estimating said timing jitter sequences includes the following steps of:

transforming the signals under test into analytic signals of complex number;

determining instantaneous phase of the signals under test based on said analytic signals;

removing linear phase from said instantaneous phase to estimate instantaneous phase noise; and

receiving said instantaneous phase noise and resampling only instantaneous phase noise data closest to the real part of zero-crossing timings of said analytic signals to produce the timing jitter sequences.

26. A probability estimating method for peak-to-peak clock skews as defined in Claim 25, wherein said step of transforming said signals under test into said analytic signals includes the following steps of:

extracting only components closest to a fundamental frequency from said signals under test to band-limit said signals under test; and

Hilbert-transforming signals resultant of said bandwidth limiting said signals under test to generate a Hilbert conversion pair of the signals under test.

27. A probability estimating method for peak-to-peak clock skews as defined in Claim 25, wherein said step of transforming said signals under test into said analytic signals includes the following steps of:

transforming said signals under test into both-side frequency spectra signals in a frequency domain;

extracting only components closest to a positive fundamental frequency
from said both-side frequency spectra signals; and

transforming resultant signals back into time domain signals.

5 28. A probability estimating method for peak-to-peak clock skews as defined
in Claim 25, wherein said step of transforming said signals under test into said analytic
signals includes the following steps of:

storing the signals under test in a buffer memory;

10 sequentially extracting the signal from the buffer memory while
overlapping a part of said extracted signals with previously extracted signals;
multiplying a window function with each of said extracted signals;

transforming each of said multiplied signal into both-side frequency
spectra signals in the frequency domain;

15 extracting only components closest to a positive fundamental frequency
of the signals under test from said both-side frequency spectra signals
transformed in the frequency domain;

transforming resultant band-limited frequency spectra signals back to
time domain signals; and

20 multiplying an inverse of said window function with the signals
transformed into the time domain to obtain band-limited analytic signals.

29. A probability estimating method for peak-to-peak clock skews as defined
in Claim 24, wherein said step of estimating the deterministic components of the clock
skews among said signals under test includes a step of finding the deterministic
components of the clock skews by receiving linear instantaneous phase of said plurality
of signals under test and determining differences among initial phase angles of said
25 linear instantaneous phase.

30. A probability estimating method for peak-to-peak clock skews as defined
in Claim 29, wherein said step of estimating the deterministic components of the clock
skews among said signals under test includes a step of receiving timing jitter sequences
of the signals under test and estimating clock edges corresponding to the signals under
test and determining an offset value of said clock edges based on correlation among
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said timing jitter sequences.

31. A probability estimating method for peak-to-peak clock skews as defined in Claim 24, wherein said step of estimating the deterministic components of the clock skews among said plurality of signals under test includes a step of finding the deterministic components of the clock skews by receiving said plurality of signals under test and determining an average value of errors in zero-crossing timings among said plurality of signals under test.

32. A probability estimating method for peak-to-peak clock skews as defined in Claim 17, wherein said step of estimating said clock skew sequences includes a step of conducting waveform clipping for the signals under test to remove amplitude modulation components in said signals under test thereby retaining only phase modulation components in said signals under test.

33. A probability estimating method for peak-to-peak clock skews as defined in Claim 25, wherein said step of estimating said timing jitter includes a step of receiving the instantaneous phase noise and removing low frequency components from said instantaneous phase noise.